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A new survey of variability in the core of M15 with TRIFFID-2

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Abstract.

A two-week campaign of high-resolution imaging of the centre of M15 using the tip/tilt correcting TRIFFID-2 camera, followed by analysis with ISIS (image matching & subtraction software), has produced the most sensitive survey to date of variable stars in the central $\sim 1' \times 1'$ - a total of 48 were detected -, and constrains the size of the dwarf nova population.

1. Introduction

M15 is a massive core-collapsed cluster, with an enormous stellar density in the central $\sim 1' \times 1'$, reflected in the scarcity of photometric variable star detections in this field. However, Ferraro & Paresce (1993) used the HST/FOC to identify 19 variable candidates. Our earlier work (Butler et al. 1998), using a TRIFFID/MAMA camera similar to that described here, resulted in light curves and periods for all but four of these, with a further 16 suspected new variables.

We made new observations in B and V simultaneously with the TRIFFID-2/MAMA camera on the 1m JKT (La Palma), over 12 nights in July 1997, with seeing of $0\farcs7$-$0\farcs8$. The 2-d photon-counted data were first sharpened post-exposure by tip/tilt correction at 1ms time resolution. The ISIS (Alard & Lupton 1998) image matching and difference imaging package was used to search for frame-to-frame variability. All star-like objects 6-sigma above the local background of the the *median* of the set of difference images were selected as candidate variables (see Figure 1). PSF-fitting photometry was performed at accurate positions for the candidate variables in the difference images. The resulting relative fluxes were converted to absolute fluxes by performing profile-fitting photometery on the reference image. The instrumental magnitudes were zeropointed against photometry of HST/WFPC2 archival images in the F555W and F439W filter system. Accurate periods (and hence lightcurves) were obtained for the set of magnitude measurements for all candidate variables using the Phase Dispersions Minimisation technique (PDM, Stellingwerf 1978). Simulations performed using an artificial image-set modeled on our M15 observations indicate that we are sensitive to RR Lyrae variables with an amplitude swing of 0.15 mag (at 80% detection probability). We also increased our sensitivity to dwarf novae (DNe) by summing all images per night prior to ISIS analysis.

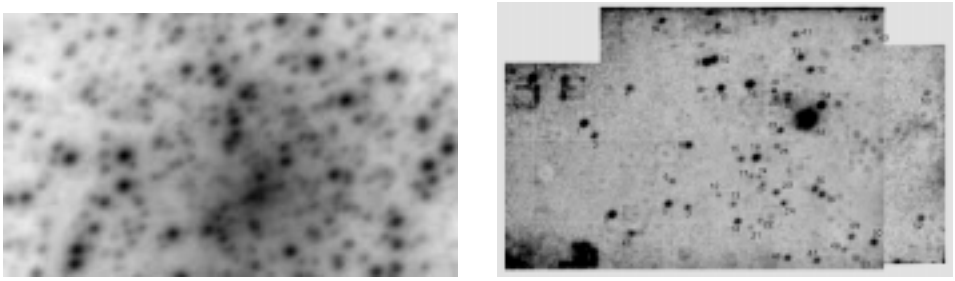


Figure 1. Left: one V-band image of M15. Right: median-difference image, clearly showing the variable candidates (numbered).

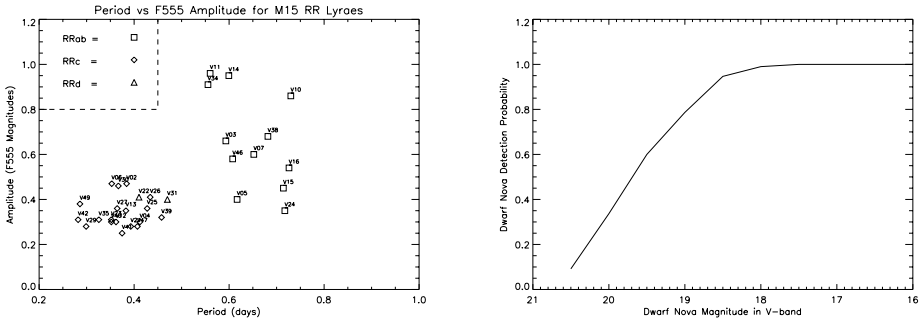


Figure 2. Left: RR Lyrae periods vs amplitudes. Right: Probability of detecting a DN in outburst for 3-4 nights versus DN test magnitude.

2. Results

We confirmed all known variables and detected 22 new ones. The lightcurve shape, amplitude, scatter and most significant period distinguished 12 RRab, 19 RRc and 2 (probable) RRd variables. The nature of 11 variables remains uncertain. We found that the core RR Lyrae population has similar periods and amplitudes to the outer population. However, in the core we find a marked increase in the ratio of RRc/RRab stars and a dearth of RRd stars, with respect to the outer reaches. The latter can be reconciled on observational grounds but the former cannot. Also detected were the LMXB counterpart AC211, a W Vir type Cepheid, and a BL Her type Cepheid - objects 20, 33 and 18 in Figure 1. Our search yielded no candidate DNe. From simulations, we estimate fewer than 10 (with 92% probability) DNe of absolute mag 4.3 (F555W/V) to exist in the studied region. This is the first such quantitative result for M15.

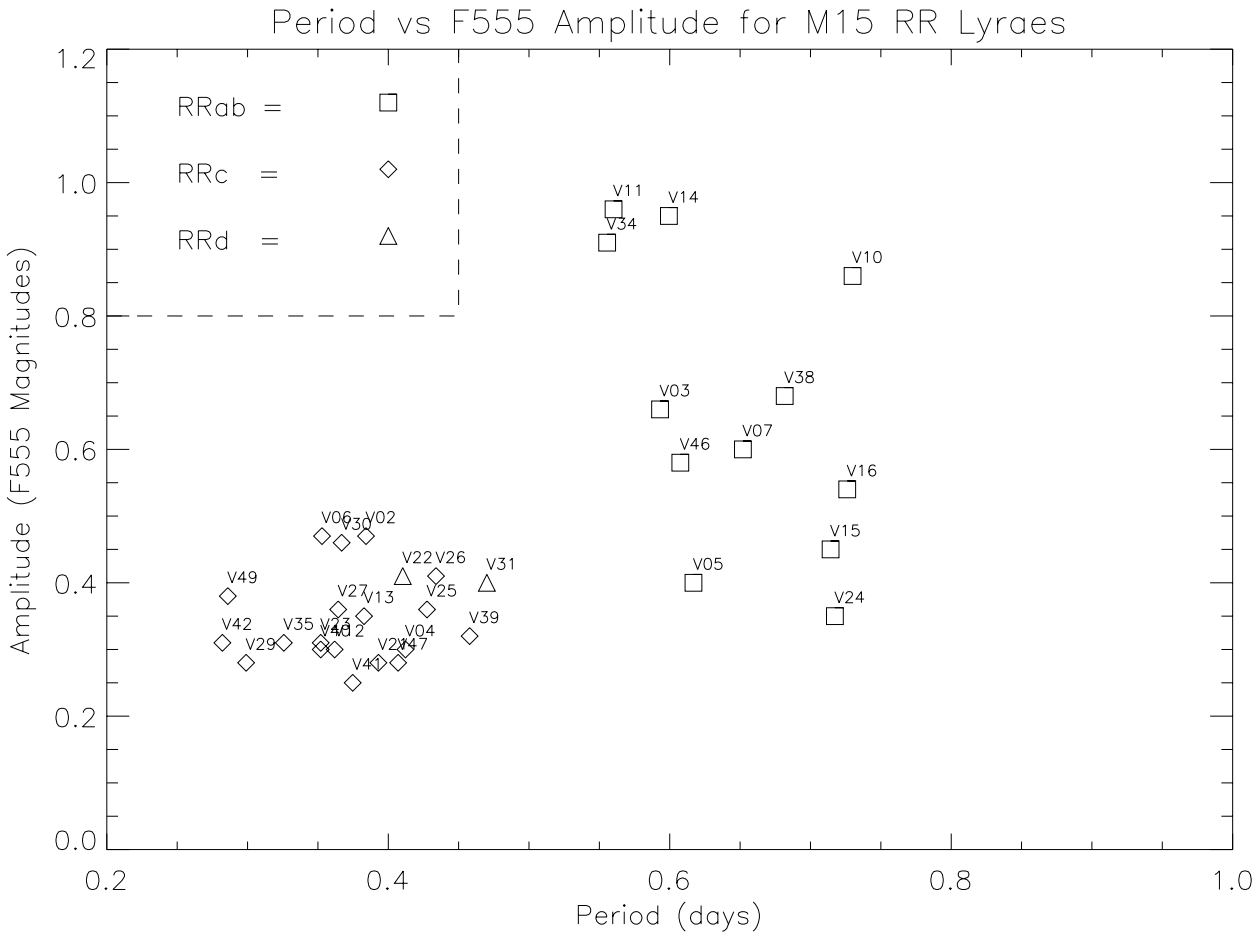
References

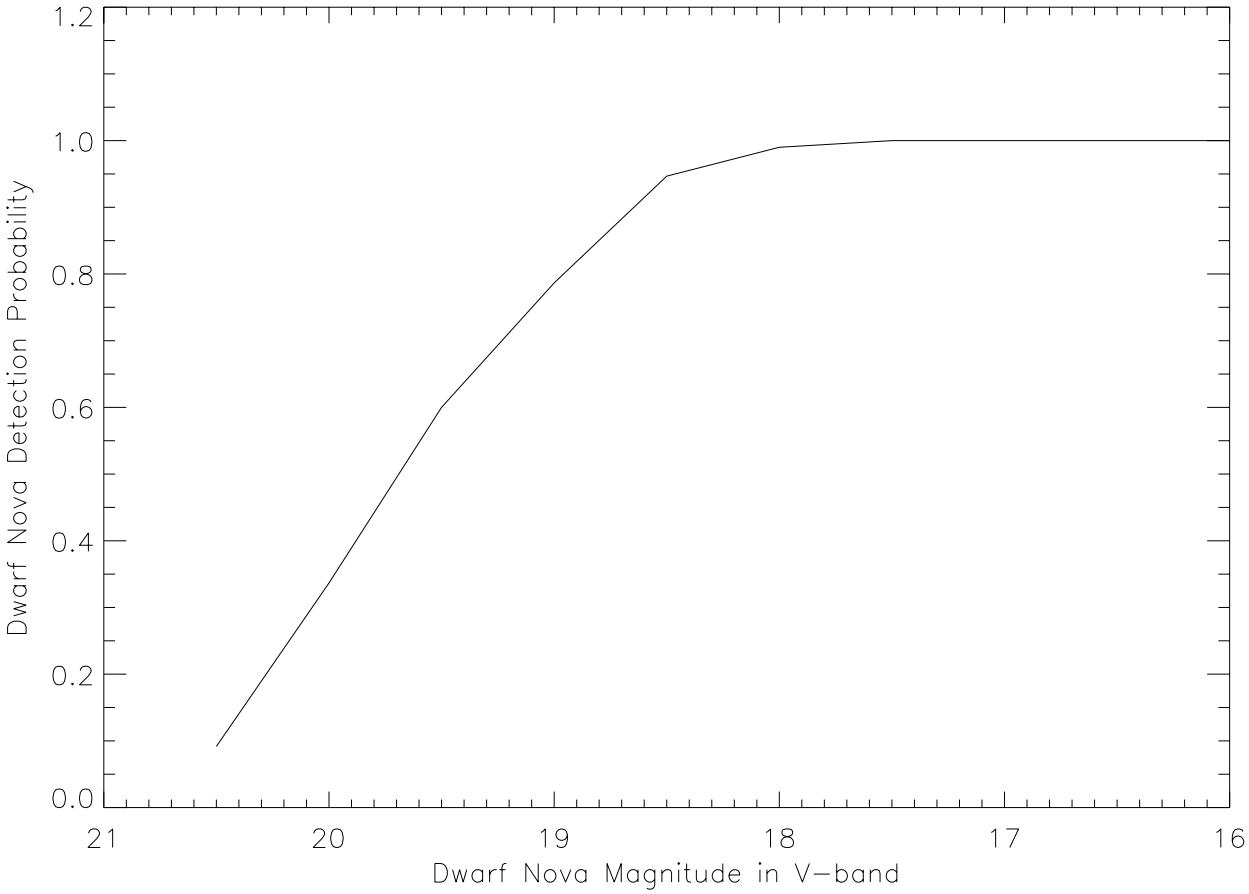
Alard, C. & Lupton, R. H. 1998, ApJ, 503, 325

Butler, R. F. et al. 1998, MNRAS, 296, 379

Ferraro, F. R. & Paresce, F. 1993, AJ, 106, 154

Stellingwerf, R. F. 1978, ApJ, 224, 953


Period vs F555 Amplitude for M15 RR Lyraes
RRab =
RRc =
RRd =
Amplitude (F555 Magnitudes)
Period (days)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.2
0.4
0.6
0.8
1.0
V11
V14
V34
V10
V03
V38
V46
V07
V16
V15
V05
V24
V06
V30
V02
V22
V26
V31
V49
V27
V13
V25
V39
V42
V35
V04
V29
V41


1.2
1.0
0.8
0.6
0.4
0.2
0.0
Dwarf Nova Detection Probability
21
20
19
18
17
16
Dwarf Nova Magnitude in V−band